NASA TECH BRIEF
Langley Research Center

Vibration Measurement by Pulse Differential Holographic Interferometry

A pulsed differential holography technique has been devised to measure structural deformations of materials that are subjected to a wide range of temperatures and other environmental conditions.

Continuous wave, time-average laser holography has been established as a method for mapping the displacements of a vibrating structure at ambient temperatures. At elevated temperatures, however, this method is severely limited by distortions induced by convection currents in the atmosphere adjacent to the test structure.

The effects of convection currents are eliminated by operating a pulsed laser in a double pulse mode which exposes the hologram two times in quick succession. During the exposure separation, the structure will deflect, but the turbulence in the medium will not change sufficiently to appreciably alter the optical path of the laser light and its reflection.

While this technique requires additions to existing pulsed holography setups, double pulsing should prove to be useful for measuring flutter, aerolastic, and other vibration characteristics of metal plates, beams, shells, and other structures. It is now possible to accomplish large area holography and to measure vibrations with large amplitudes. It is also no longer necessary to isolate the test structure in a vacuum chamber in order to eliminate or reduce atmospheric interferences.

Pulse differential holography is a variation on double-exposure holography, in which an interferogram is recorded. In this technique, a hologram is made of the test object. The object is then subjected to loads which cause it to deform, and a second hologram is made on the same piece of photographic film. Two images are produced when the developed film is illuminated by a laser light, one image from the undeformed object and the other when it is deformed. The light waves which form the two images interact with each other to create interference patterns. Analysis of the patterns reveals the surface deformations of the object caused by the load.

The timing of the two exposures, in pulsed differential holography, is carefully controlled to be synchronized with the deflection of the object being measured. The optimum time interval between exposures is dependent on several factors such as the number of fringes desired, vibration amplitude and frequency, and temperature of the structure. Too long a period between pulses results in fringes that are perturbated by the convection currents surrounding the object, while the shorter time intervals permit operation at higher temperatures and higher vibration amplitudes or frequencies.

The magnitude of the structural deformation is determined by counting the number of interference fringes that appear on the hologram. The first dark fringe corresponds to a deflection of one-quarter wavelength of the laser light being used, the second corresponds to three-quarters of a wavelength, and so on. The larger the slope in the surface of the object, caused by bending or deflection from an impact or other vibration-producing mechanism, the closer the spacing between fringes.

Using this technique, vibration amplitudes have been successfully measured on stainless steel panels heated to temperatures from 394 K (250° F) to 1394 K (2050° F). For these experiments the pulse duration was 50×10^{-9} second, while the interval between pulses was 50 microseconds.

(continued overleaf)

Note:

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)

Reference: NASA CR-2028 (N72-29543)
Pulsed Differential Holographic Measurements of Vibration Modes of High-Temperature Panels

Patent status:

NASA has decided not to apply for a patent.

Source: D. A. Evensen and R. Aprahamian of
TRW, Inc.
under contract to
Langley Research Center
(LAR-11092)